MULTISENSOR SYSTEM USING LPC2148 MICROCONTROLLER

A thesis submitted in partial fulfillment

of the requirement for the degree of

Bachelor of Technology in Electronics and Communication engineering

By

Prashant Kumar

Roll No- 110EC0421

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Bachelor of Technology in Electronics and Instrumentation engineering

By

Shashank Singh

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Departments of Electronics and Communication Engineering

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Under the guidance

of

Prof. S.K Das

Department of Electronics & Communication Engineering

National Institute of Technology, Rourkela

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DECLARATION

We hereby declare that the project entitled **"Multisensor System using LPC2148Microcontroller"** is a record of our original work done under **Prof. S.K Das, National Institute of Technology, Rourkela.** Throughout this Project wherever contributions of others are involved; every effort has been made to acknowledge this clearly with due reference to literature. This project work is being submitted in partial fulfillment of the requirements for the degree of Bachelor of Technology in Electronics and Communication Engineering & Bachelor of Technology in Electronics and **Instrumentation** at National Institute of Technology, Rourkela for the academic session 2010-2014.

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CERTIFICATE

This is to certify that the thesis entitled, "**Multisensor System using LPC2148 Microcontroller**" submitted by Prashant Kumar and Shashank Singh in partial fulfillment of the requirements for the award of Bachelor of Technology degree in **Electronics and Communication Engineering & Electronics and Instrumentation Engineering** during session 2010-2014 at **National Institute of Technology, Rourkela** and is an authentic work by them under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other university/institute for the award of any Degree or Diploma.

Date:12/05/2014

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ABSTRACT

“MULTISENSOR SYSTEM USING LPC2148 MICROCONTROLLER’ is designed for sensing physical parameters such as temperature, distance and detection of object with the help of various analog sensors which can be helpful in various industrial applications and also in SMART home appliances. For temperature sensing, LM35DZ precision integrated- circuit temperature sensor is used which can take the input power in the range of 4 to 40V and gives the output in the range of 0 to 5.2V and operates in the range of 2°C to 150°C. For object detection TSOP1738 receiver and IR transmitter is used, which detects the presence of any obstacle between them. Since TSOP1738 carrier frequency is in the range of 38KHZ, an IR transmitter of same frequency range is needed which is designed using an IC 555 astable multivibrator. Proximity sensor is designed using an infrared emitter and detector pair which measures the distance of an object from the sensor. Its range is from 0 to 5cm. The outputs of the above mentioned sensors are interfaced with the ADC and the converted data is displayed on an LCD.

Keywords: Multisensor, LPC2148, Temperature, LM35DZ, TSOP1738, IR transmitter, Proximity sensor, IC 555, ADC, LCD, astable multivibrator etc.

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Chapter 1

Literature Review

1.1 Introduction

Sensors are devices which detect and measure the non-electrical parameters such as temperature, pressure, speed, distance, weight etc. they do this by converting these physical parameters into signals which can be measured electrically.

Sensors have become the part and parcel of our day to day life. From big industries to small households, sensors are being utilized by everyone. In most of the industries maintaining exact temperature and other environmental conditions are one of the top priorities.

So, we are designing a multi-sensor system which can be used by these industries to overcome these problems and provide a better, reliable, accurate and cost effective solution. For this purpose we are interfacing various sensors such as temperature sensor, proximity sensor and object detection sensor with the help of a microcontroller (LPC2148). Since, the outputs of the sensors are analog in nature, so, after signal conditioning, they are connected to the ADC pins of the microcontroller. The result is displayed on an LCD which is interfaced with the microcontroller.

1.2 Hardware Requirements:-

1. LPC 2148 Development Board
2. ADC
3. LCD (2X16)
4. DB-9 cable
5. Sensors
6. IC 555 Timer
7. IC 7805 voltage regulator
8. Resistors
9. Capacitors
10. AC Supply

1.3 LPC 2148 Development Board

LPC 2148 Development Board [2] is a developmental tool based on LPC 2148 ARM7TDMI microcontroller with 512KB on-chip memory. It is suitable for developing applications which require high speed data communication, real time clock for data checking etc.

The ARM7TDMI-S is a general purpose 32-bit microprocessor, which provides high performance and uses very low power. It uses Reduced Instruction Set Computing (RISC) principles in its architecture which is much more simple and powerful than those Complex Instruction Set Computing (CISC). ARM uses pipeline technique to execute instructions which offers high performance, very low power consumption and less silicon die area. The ARM7 three stage pipeline has independent fetch, execute and decode stages.

The development board has 40 KB static RAM and 512 KB of in built flash memory. It supports In-System Programming/In-Application Programming (ISP/IAP) with the help of a boot loader software already present in it. It has two 32-bit timers/counters, one PWM unit (six outputs) and a watchdog, two 10-bit ADCs which can be used for 14 analog inputs and one 10- bit DAC which give variable analog output. It also features a low powered real time clock with 32 kHz clock input. On the top of all it has 50 pin expansion header which provides for up to 45 of general purpose I/O pins (0V-5V). Besides all these features this board also provides devices such as LEDs, Buzzer, IR receiver, user switches and a 16X2 LCD for display.

Board Overview

Figure 1.1: LPC2148 Development Board

1. LPC2148 Plug-in module
2. 3V cell holder for RTC
3. UART1 DB9 connector
4. UART0 DB9 connector
5. 50-pin expansion header
6. 2X5 JTAG header
7. 9-12V AC/DC socket

8. ON/OFF slide switch
9. Boot loader switch
10. Microcontroller reset switch
11. USB connector B-type
12. Jumpers for LCD interface
13. Jumpers for Switches
14. Jumpers for Trimpots
15. Jumpers for Buzzer and IR Receiver
16. Jumpers for LEDs
17. Jumpers for selection between UART1 and Xbee
18. Jumpers for SPI – SD/MMC interface
19. Jumpers for I2C EEPROM
20. SD/MMC card socket
21. 16X2 character LCD
22. Four user switches
23. Two trimpots connected to ADC
24. Four user LEDs
25. Buzzer
26. TSOP1738 IR Receiver
27. Xbee module interface
28. ULN2003 driver side header
29. L293D o/p header
30. Jumpers for ULN2003

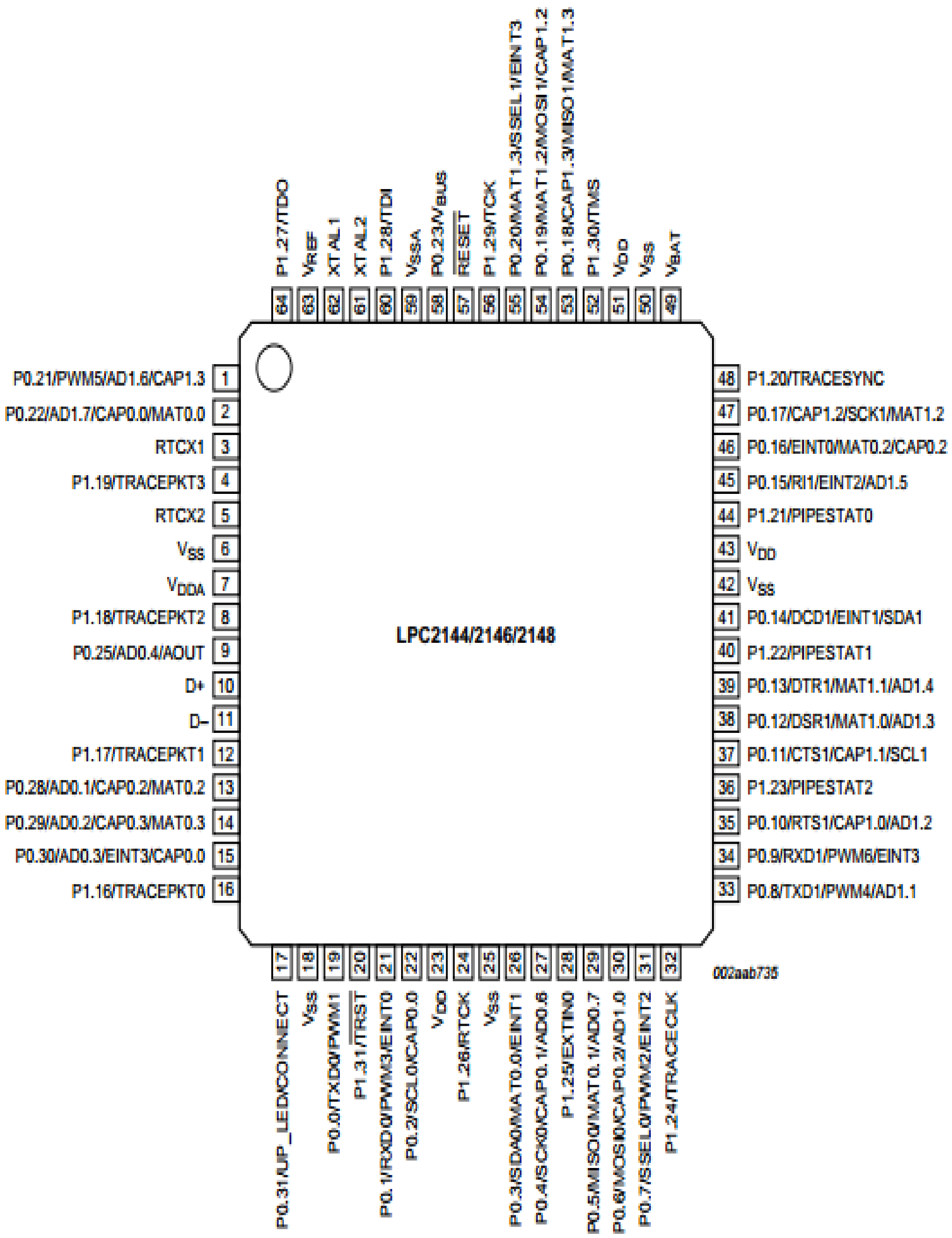

Figure 1.2: pin configuration of lpc2148 [2]

Pin Description

P0.0 to P0.31- Port 0: Port 0 is a 32-bit I/O port with one direction controls for each bit. 28 pins of the Port 0 can be used as a general purpose bi-directional I/Os while P0.31 provides output functions only. The operation of port 0 pins depends upon the pin function selected via the pin connect block. Pins P0.24, P0.26 and P0.27 are not available for use.

P1.0 to P1.31-Port 1: Port 1 is a 32-bit bi-directional I/O port with one direction controls for each bit. The operation of port 1 pins is decided by the pin function selected via the pin connect block. Pins 0 through 15 of port 1 are not available for use.

RESET: A LOW on this pin resets the device, which causes I/O ports and peripherals to return to their default states.

XTAL1: Input to the oscillator circuit and internal clock generator circuits.

XTAL2: Output from the oscillator amplifier.

RTCX1: Input to the RTC oscillator circuit. It can be left floating if the RTC is not used.

RTCX2: Output from the RTC oscillator circuit. It can be left floating if the RTC is not used.

VSS: (Ground) 0 V reference

VSSA: (Analog Ground) 0 V reference. This should technically be the same voltage as VSS, but should be separated to minimize noise and error. This pin must be grounded if the ADC/DAC are not used.

VDD: 3.3 V Power Supply: This is the power supply voltage for the core and I/O ports.

VDDA: Analog 3.3 V Power Supply: This should technically be the same voltage as VDD, but should be separated to minimize noise and error. This voltage is used to power the ADC(s) and DAC (where available). This pin must be tied to VDD when the ADC/DAC is not used.

VREF: A/D Converter Reference: This should technically be the same voltage as VDD, but should be separated to minimize noise and error. Level on this pin is used as a reference for A/D convertor and DAC (where available). This pin must be tied to VDD when the ADC/DAC are not used.

VBAT: RTC Power Supply: A 3.3 V on this pin supplies the power to the RTC.

1.4 GPIO and the expansion header

The GPIO pins can be used for driving LEDS, reading digital signal, generating triggers for external components, controlling external devices and what not. LPC-2148 has two 32-bit wide GPIO ports. In LPC-2148 MCUs most of the PINS are multiplexed i.e. these pins can be configured to provide different functions. All pins of the ports on LPC-2148 microcontroller can be accessed with the help of the 50 pin main expansion header. The expansion header enables the user to interface external peripherals/devices to LPC-2148 microcontroller. It is also has a 3.3V supply which can be utilized to power external devices. To use the expansion header, it is necessary to disconnect the peripherals connected to these pins by removing the jumpers which links these pins to the peripherals. The expansion header is shown below. [2]

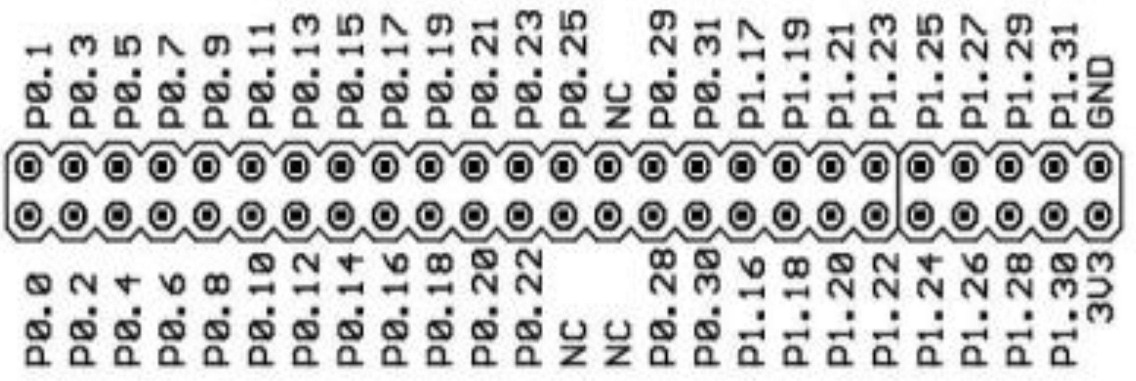

Figure 1.3: GPIO pin description

1.5 ADC

The main problem in interfacing sensors like LM35, or proximity sensor is that they provide analog voltage outputs depending on the physical quantity that they are designed to measure. A microcontroller however, takes only digital inputs. They can differentiate in only high level or low level pin. For example, an input more than 2.5V is taken as 1 and input less than 2.5V is taken as 0. To solve this, microcontrollers have built-in ADCs which convert the analog voltage in a digital form. This helps us to interface the types of sensors which give analog output.

The resolution of an ADC indicates its accuracy. Common ADCs are 8-bit, 10-bit and 12 bit. LPC-2148 has two 10 bit successive approximation analog to digital converter with input multiplexing among 6 or 8 pins (ADC0 and ADC1). A 10-bit ADC will break the 0-5V range in 5/1023=4.8mV approx. It also has Power-down mode. The range of the ADCs present in the board is 0V to typically 3V. The conversion time this ADC is 2.44µs. It also supports Burst conversion mode for single or multiple inputs.

The board has two trimpots connected to AD0.1 and AD0.2 present on the LPC2148 microcontroller. The jumper positions are as shown in the below figure. Jumper AN1 represents trimpot AN1 and AN2 represents trimpot AN2. The voltage range of trimpot lies between 0-3.3V. [2]

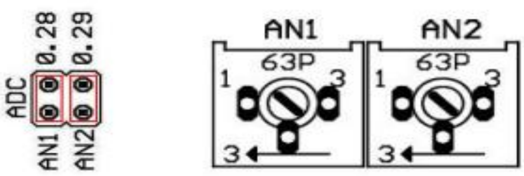

Figure 1.4: Trimpots pin

1.6 Liquid Crystal Display

A liquid crystal display is a distinctive thin flat panel that can let light pass through it, or can block the light. (Unlike an LED it does not produce its own light). It is built of many blocks, and each block can be in any shape. Each block is filled with liquid crystals that can be made clear or solid, by changing the electric current to that block. Liquid crystal displays are often abbreviated LCDs.

A common LCD has two registers: - Command and Data. The command register stores the command instructions received by the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data that is to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. [2]

Figure 1.5: LCD

The LPC-2148 development board has a 4-bit HD44780 based LCD interface. LPC-2148 has a 2X16 LCD which means it can display 16 characters per line and there can be two such lines. The jumper positions and port pins are as shown in the below figure. The B/L jumper setting is used to control LCD backlight. On removing this jumper LCD backlight will turn OFF.

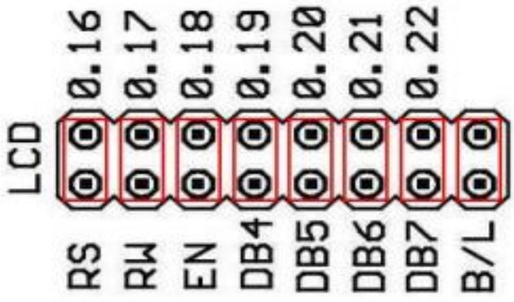

Figure 1.6: Port pins connected to LCD

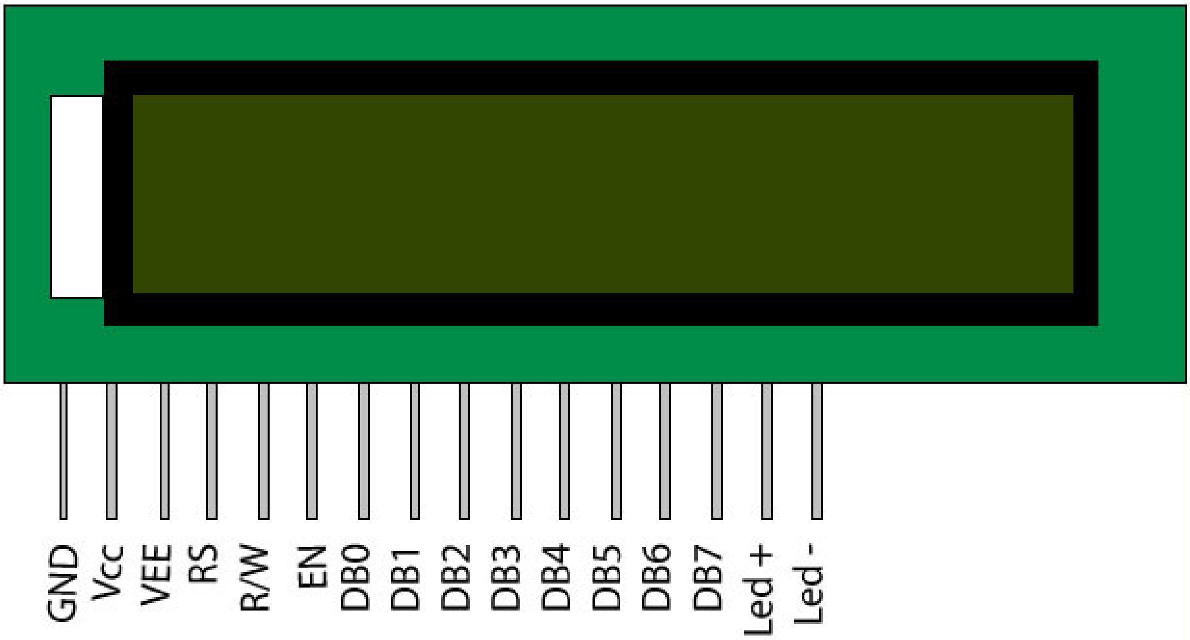

Figure 1.7: Pin diagram of LCD

Pin Description

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7

Figure 1.8: pin description of LCD

Programming of an LCD involves three basic steps which are as follows:-

1. LCD initialization
2. Giving command to read a data
3. Giving command to display a data

LCD Command Codes

Code (Hex)	Command to LCD Instruction Register
1	Clear display screen
2	Return home
4	Decrement cursor (shift cursor to left)
6	Increment cursor (shift cursor to right)
5	Shift display right
7	Shift display left
8	Display off, cursor off
A	Display off, cursor on
C	Display on, cursor off
E	Display on, cursor blinking
F	Display on, cursor blinking
10	Shift cursor position to left
14	Shift cursor position to right
18	Shift the entire display to the left
1C	Shift the entire display to the right
80	Force cursor to beginning to 1st line
C0	Force cursor to beginning to 2nd line
38	2 lines and 5x7 matrix

Figure 1.9: LCD commands [3]

3.3 DB-9 Cable

Db-9 [6] is a common connector type used for serial communication which consists of 9 pins for the male connector and 9 holes foe the female connector. It works on according to the RS232 serial interface standards.

Pin out of DB-9 connector commonly used for serial communication via serial ports (RS232).

Pin	SIG.	Signal Name	DTE (PC)
1	DCD	Data Carrier Detect	in
2	RXD	Receive Data	in
3	TXD	Transmit Data	out
4	DTR	Data Terminal Ready	out
5	GND	Signal Ground	-
6	DSR	Data Set Ready	in
7	RTS	Request to Send	out
8	CTS	Clear to Send	in
9	RI	Ring Indicator	in

Figure 1.10: pin out of DB-9

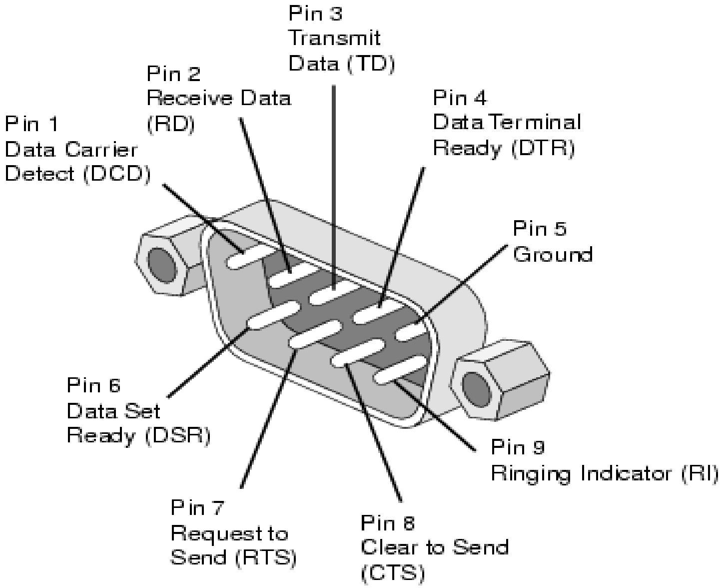

Figure 1.11: pin configuration of DB-9 male connector [6]

3.4 Sensors

Sensor is a sophisticated device whose function is to detect and measure any non-electrical parameters such as temperature, pressure, humidity, speed, weight etc. and convert it into a signal which can be measured electrically for e.g. voltage.

For the implementation purpose sensor should be accurate, not dependent on environmental conditions, with wide range of values and high resolution, linear, cost effective and highly calibrated. So for this purpose generally IC sensors are used.

In our project we have mainly implemented four sensors.

1. LM 35DZ temperature sensor: this sensor belongs to LM 35 series, which is precision integrated temperature sensor, whose output voltage is linearly proportional to the centigrade temperature. Generally LM 35 series gives temperature in the range of -55 to +150℃ but our sensor gives output from 2 to 150℃.

   It's low output impedance, linear output and precise inherent calibration makes interfacing very simple without any need of signal conditioning. It operates from 4 to 40v and gives 10milli volt analog output for per centigrade (℃) change in temperature. So analog to digital converter is used to convert this output to binary output. [4]

Figure 1.12 LM35DZ pin out diagram [4]

2. Proximity sensor: There are various types of proximity sensors for detecting the object and its design is based upon principles like variable reluctance, eddy current loss, saturated core, and Hall effect etc. Some of the non-contact proximity sensors are inductive proximity sensors, capacitive proximity sensors, ultrasonic proximity sensors, and photoelectric sensors. In our project two proximity sensors for entirely different purposes are used. [5]

2.1 **Infrared transmitter and receiver sensor using IR LED and TSOP1738 receiver**: These sensors are used for remote control system and also for detection of object when object approaches within the range of the sensor or between the IR pair sensors.

This sensor can be easily made using IC 555 timer, IR led and TSOP1738 receiver.

TSOP1738 receiver: it is a three terminal device with VCC, GND and VOUT. It is an active low output device using a 5V power supply and can be directly connected to microcontroller. It is highly immune to ambient light and other electrical disturbances and is able to transfer data up to 2400 bits per second. The Pulse Coded Modulating carrier frequency of TSOP1738 is 38KHZ, so we need an astable multivibrator of 38khz and IC 555 timer is appropriate for this. [5]

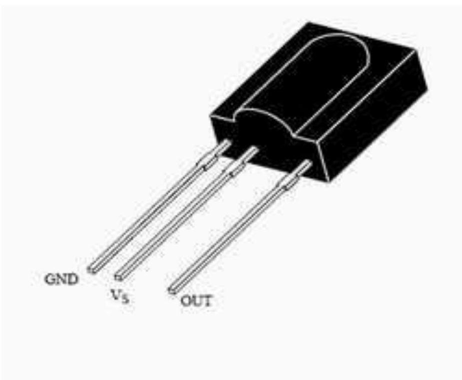

Figure 1.13: TSOP1738 IR receiver [2]

IC 555 Timer: we have used IC 555 as astable multivibrator. The 100μF capacitor (C1) is used for reducing ripple in power supply. 1st and 8th pins are used to give VCC and GND respectively. 4th pin is connected to VCC as it is a reset pin. For avoiding high frequency noises, 5th pin is grounded via capacitor. he time period of oscillation is determined by Capacitor C2, Resistor R1, and R2. Capacitor C2 charges to VCC via R1 and R2 and it discharges through R2 and 7th pin of 555. The output is taken from the 3rd pin of IC. [5]

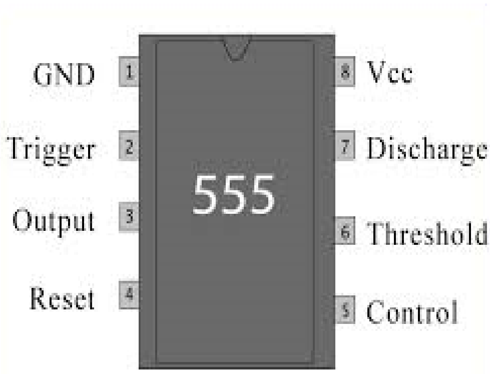

Figure 1.14: IC 555 [5]

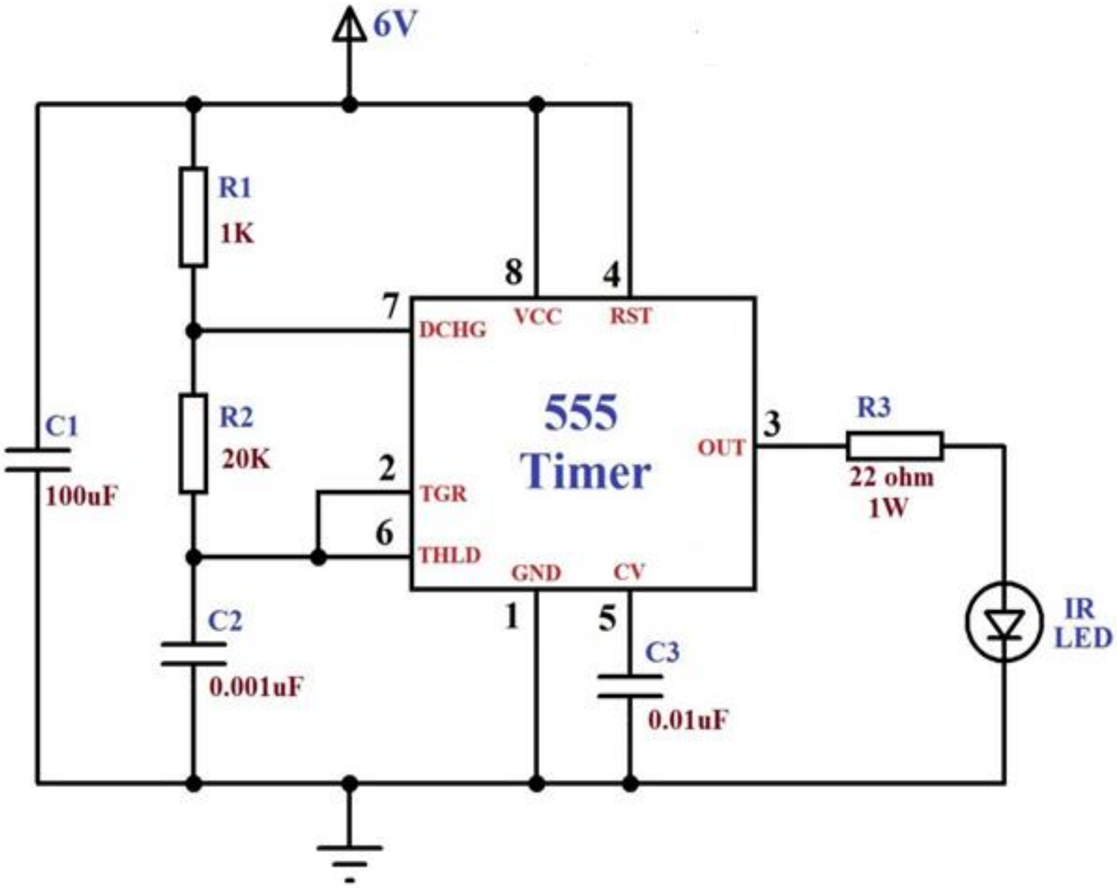

Figure 1.15: Circuit diagram of IR transmitter [5]

2.2 IR Emitter and Detector pair: In our project we have used this sensor as distance measurement sensor. This circuit is generally used in line follower robot. Infrared emitter detector pair sensors are easy to implement, but need some level of calibration and testing.[5]

In this circuit it gives maximum range of 5 cm and after calibration it gives output of 640mv per centigrade and this analog output is given to analog to digital converter of the microcontroller.

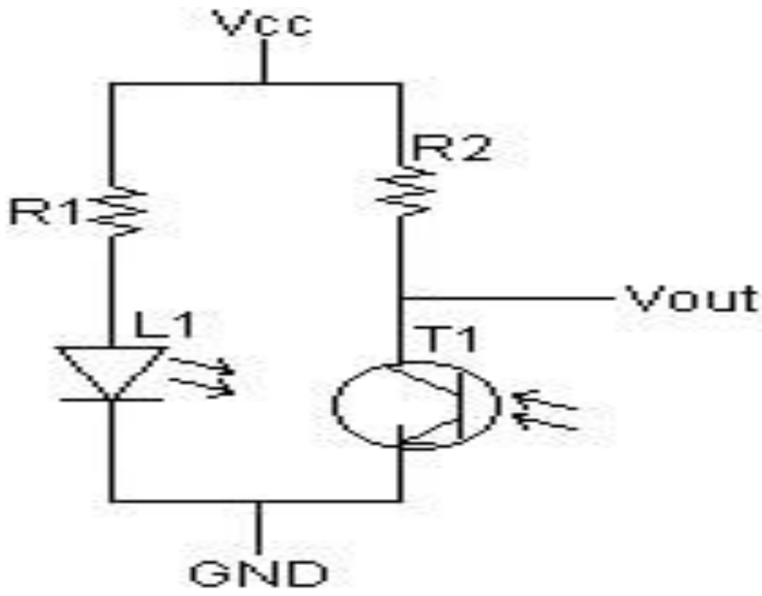

Figure 1.16: IR Emitter and Detector pair circuit [5]

3.5 IC 7805 (voltage regulator)

It belongs to 78XX series of fixed linear regulated IC voltage. Voltage regulator IC maintains the output value to constant value. Here XX represents the fixed output voltage. So 7805 indicates constant output of +5V.

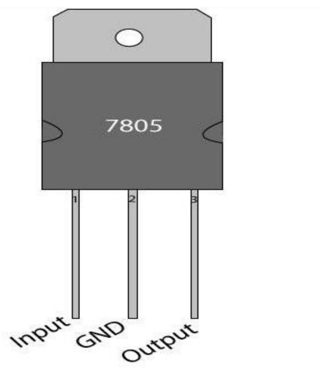

Figure 1.17: IC 7805 pin configuration [4]

Chapter 2

SOFTWARE

REQUIREMENTS

2.1 INTRODUCTION

Software's used for programming lpc2148 microcontroller and burning in microcontroller.

1. Keil µVision4: Keil is based on Integrated Development environment (IDE). It consists of a code editor, a compiler, a debugger and what you see is what you get (WYCIWYG) editor in a single package, which is used for programming in embedded c and generate Hex code for burning in microcontroller.
2. Flash Magic: this software is used for burning the generated Hex file into microcontroller.

2.2 Starting of keil and creating project

1. Open the Keil IDE. The initial screen will appear like this.

   The Keil IDE main window in is divided into three areas.

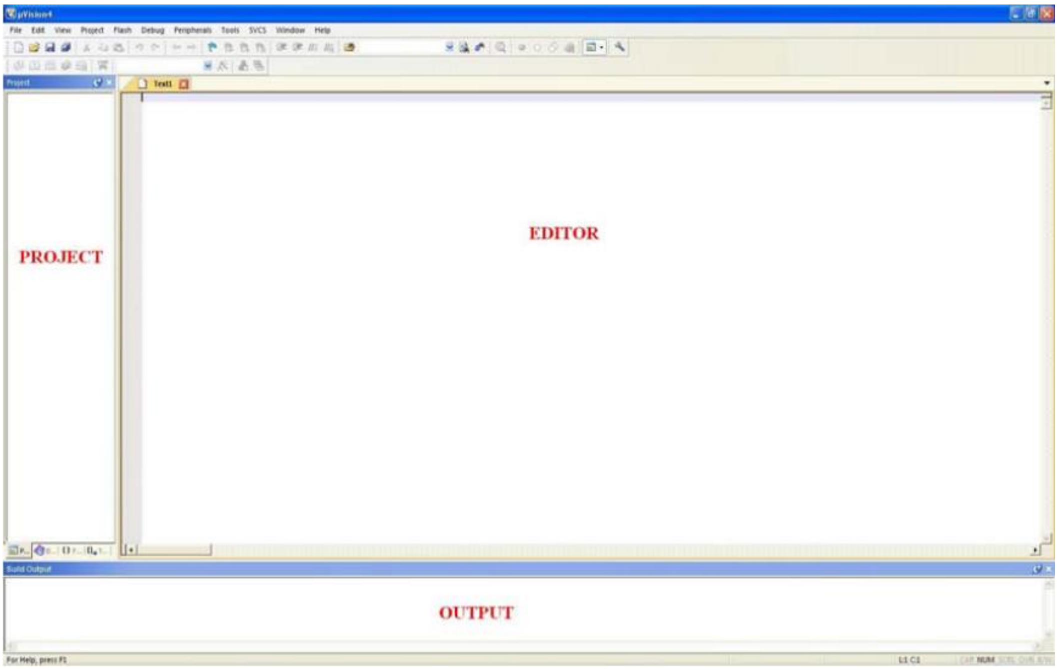

Figure2.1: Keil uvision initial window [1]

Editor: Here .c file and and .h files are written and edited.
Project explorer: It shows the project tree.

Output window: Shows messages related with compiling, project building and debugging.

2. Click on project->new uvision project.

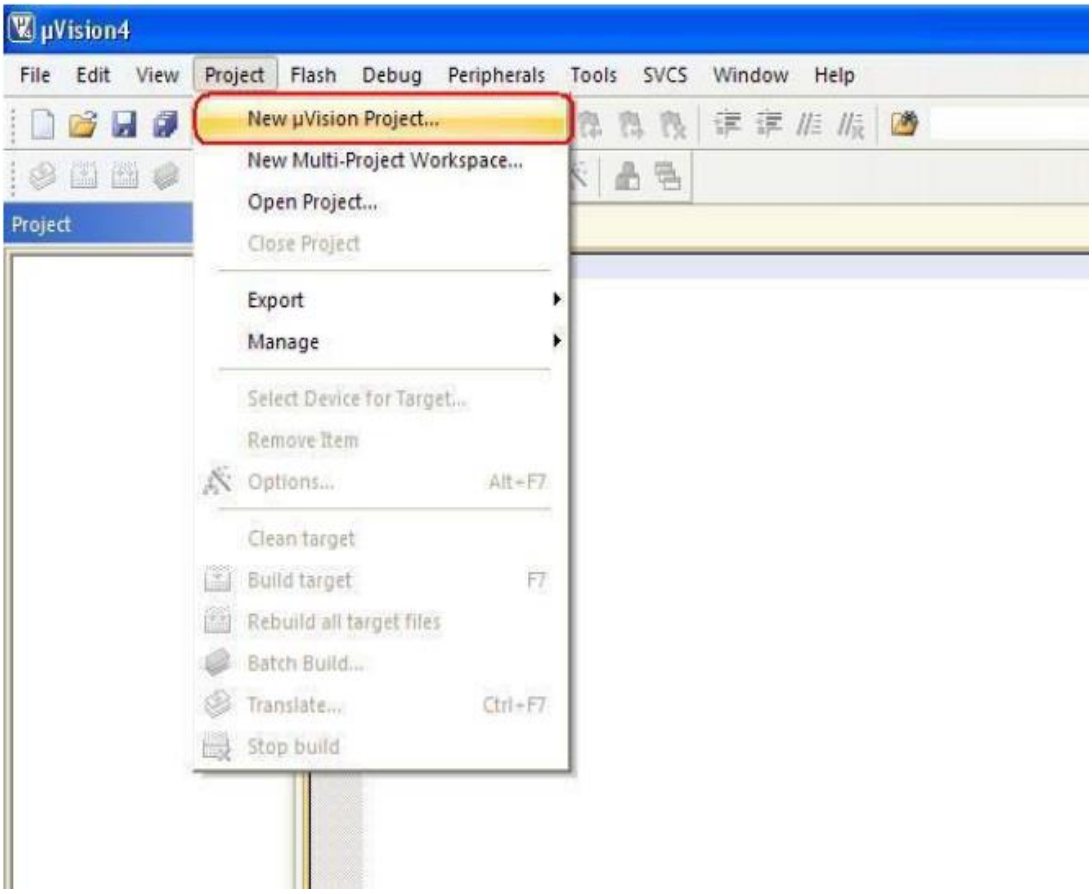

Figure 2.2: creating new project [1]

3. Follow these steps now

    - choose file name , for e.g. multisensor.uvproj and its saving location
    - select the device for target ‘target1’ i.e. NXP->lpc2148 and press ok.
    - now select yes to copy startup.s file, this is for initial configuration and right click the target option in project window and select output->create hex file option.

4. Creating and writing program

    - Click New and save file with name main.c
    - Write the program.

5. Save the program.

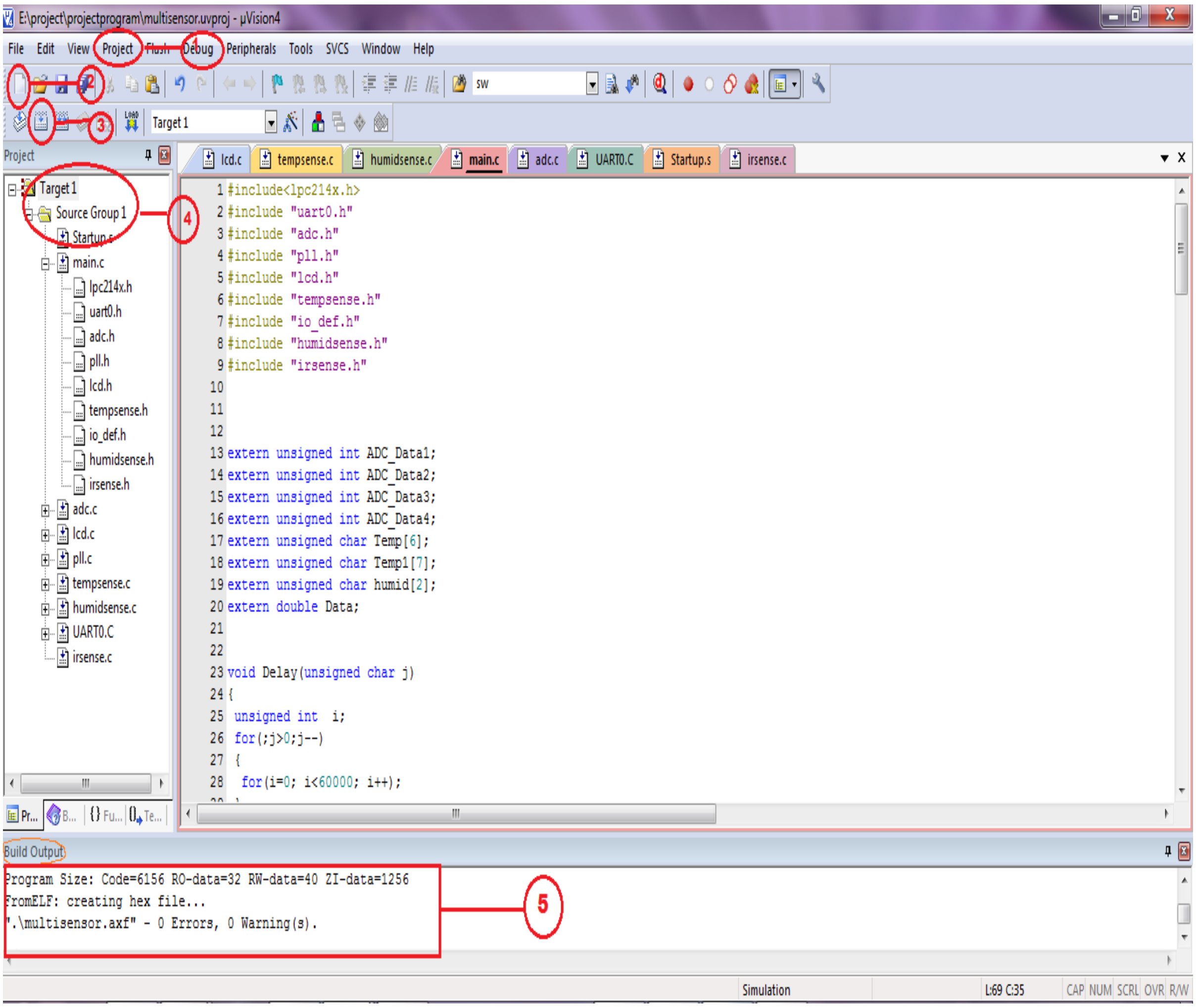

Figure 2.3: keil uvision main window [1]

6. Right click source group and add files to source group and select saved files to add to the program.
7. Click on Build for compiling the program and see for errors in output window, if any to correct it.

Reference from figure 2.3

1. Project- for creating new project.
2. New- for creating new file.
3. Build- for compiling and creating hex file.
4. Target and Source group.
5. Output window- for seeing build process and checking for errors.

2.3 Burning of program using Flash Magic

After selecting Build option, it will create hex file with same name as project name and this file is used for burning program in flash memory of microcontroller using flash magic. This is done by serial communication using UART (Universal Asynchronous Receiver/Transmitter) by connecting PC with UART0 of microcontroller using Rs232 (DB 9 cable).

Steps involved in burning

- Hex file is created
- Pc is connected with lpc2148 microcontroller using DB-9 and uart.
- Open Flash magic and select lpc2148 microcontroller, select assigned COM port.
- Set the Baud Rate generally 9600 (the baud rate of both microcontroller and pc should be same for burning) and crystal frequency to 12 MHZ.
- Select erase blocks used by hex file and verify after programming and load the hex file and click on start to burn the hex file.

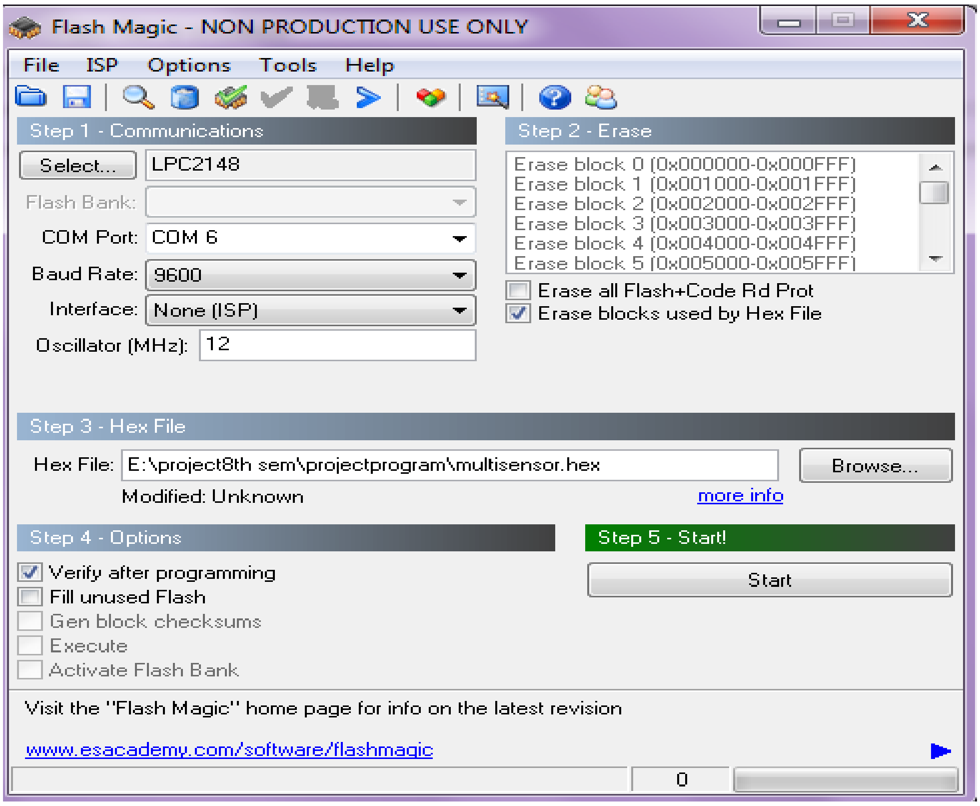

Figure 3.4:Flash magic [1]

2.4 Algorithm

Step1: Include all Header files

Step2: initperipherals();

it includes initialization of i/o pin, uart, ADC and LCD.

Step3: Activate the ADC

Step4: ADC0read (channel1);

It is used to read the output of sensor connected to given ADC channel1.

Step5: DECtoASCIItemp(ADC_data1);

conversion of ADC value to digital Data and then converting to centigrade.

Step6: LCD_command() and LCD_display(temp);

It is used for displaying converted temperature in LCD.

Step7: Delay_ms(1000);

delay of 1 second for next input.

Step8: ADC0read(channel2);

It is used to read the output of the sensor connected to given **ADC channel2**

Step9: DECtoASCIIIR(ADC_data2);

It is used for conversion of ADC value to digital Data and then converting to Centimeter.

Step10: LCD_command() and LCD_display(IR);

It is used for displaying converted Distance of object in LCD.

Step11: Delay_ms(1000);

delay of 1 second for next ADC channel input

Step12: ADC0read(channel3);

It is used to read the output of the sensor connected to given ADC channel3.

Step13: DECtoASCIITSOP(ADC_data3);

conversion of ADC value to digital Data and then converting to Centimeter.

Step14: LCD_command() and LCD_display(TSOP);

It is used for displaying converted Distance of object in LCD.

Chapter 3

Implementation of Multisensor System

3.1 Block Diagram of Hardware Implementation

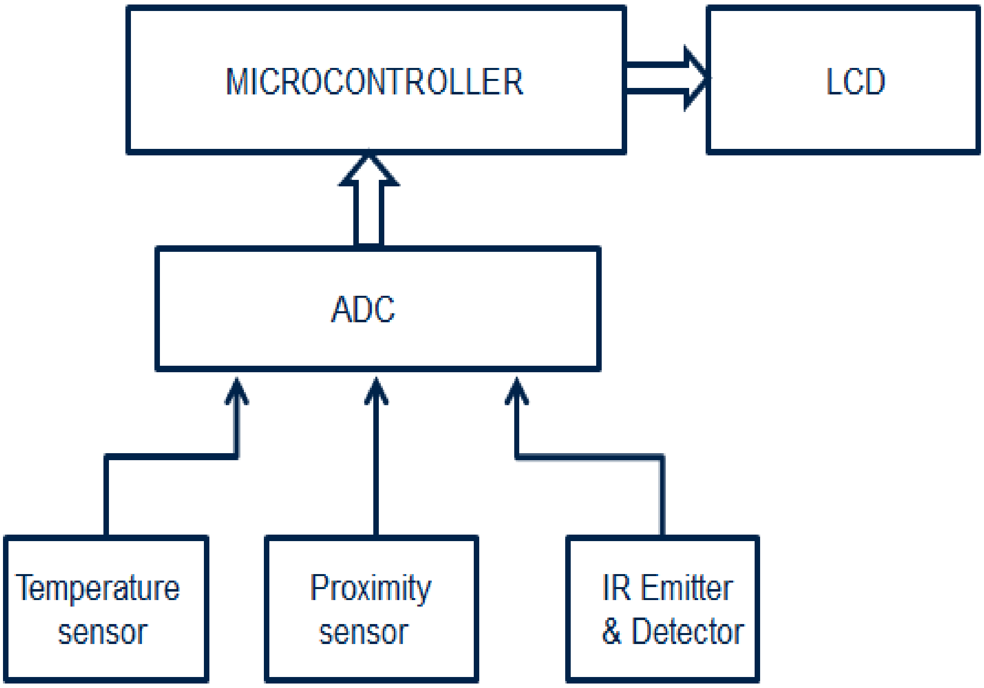

Figure 3.1: Block Diagram of Multisensor System

3.2 Implementation of Multisensor system

- The output pin of LM35 sensor, proximity sensor and IR emitter and detector sensor is connected to ADC of microcontroller.
- LM35 sensor is connected to pin p0.28, proximity sensor to pin p0.29 and IR emitter and detector pair is connected to pin p0.25. These are the ADC pin of microcontroller.
- LCD is connected to the port p0 of the microcontroller.
- RS is connected to pin p0.16, RW to p0.17, EN to p0.18, DB4 to p0.19, DB5 to p0.20, DB6 to p0.21 and DB7 to p0.22.
- The program is burned into microcontroller and microcontroller is entered into boot load mode by pressing Boot switch and then Reset switch.
- By this ADC and LCD of the LPC2148 microcontroller gets activated for interfacing different sensors and output of different sensors was displayed in the LCD.
- For temperature sensor temperature was displayed in Centigrade, for proximity sensor “obstacle detected” was displayed and for IR emitter and detector distance of the obstacle was displayed

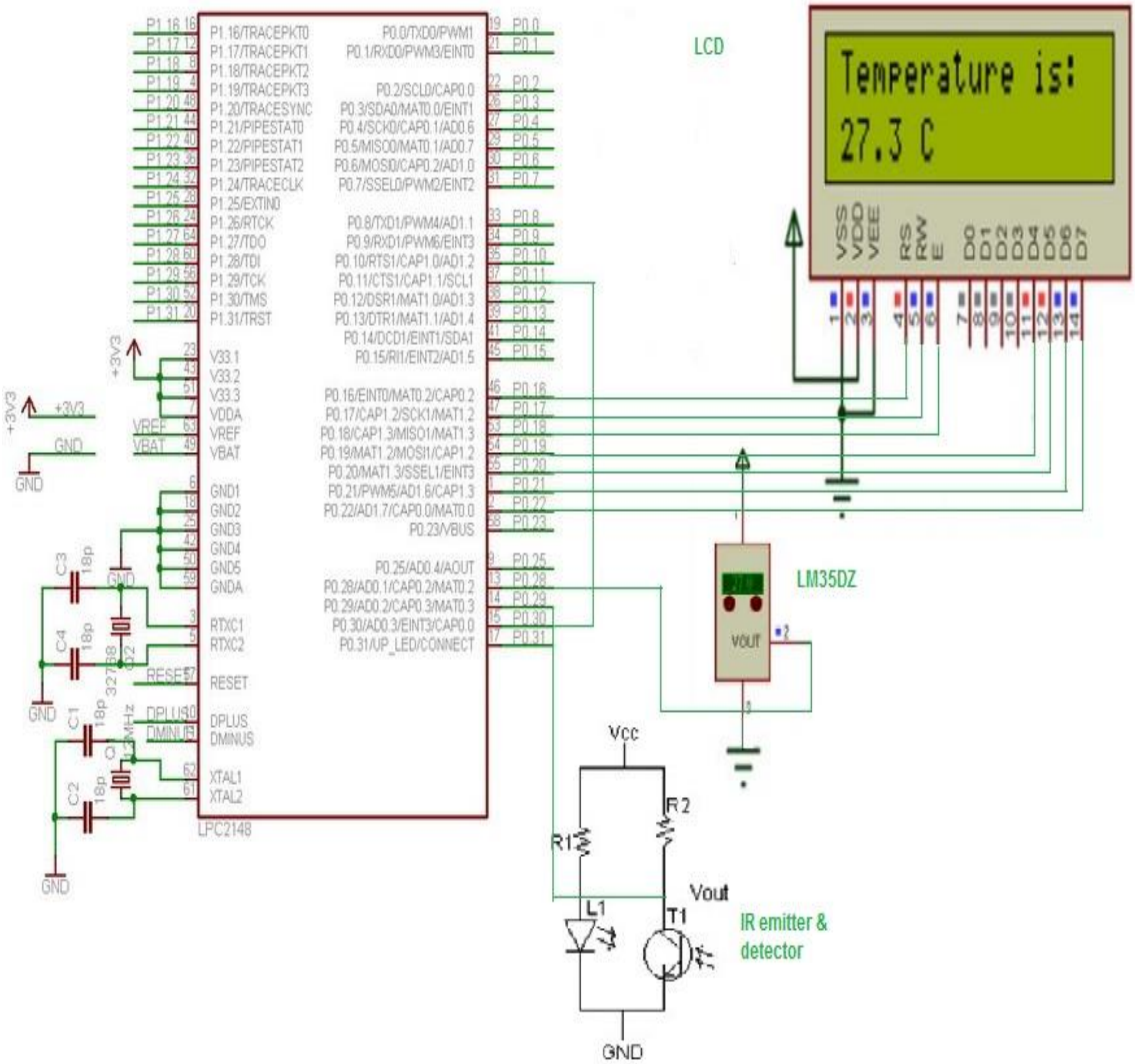

Figure 3.2: Schematic of LPC2148 microcontroller

3.3 Final setup of project

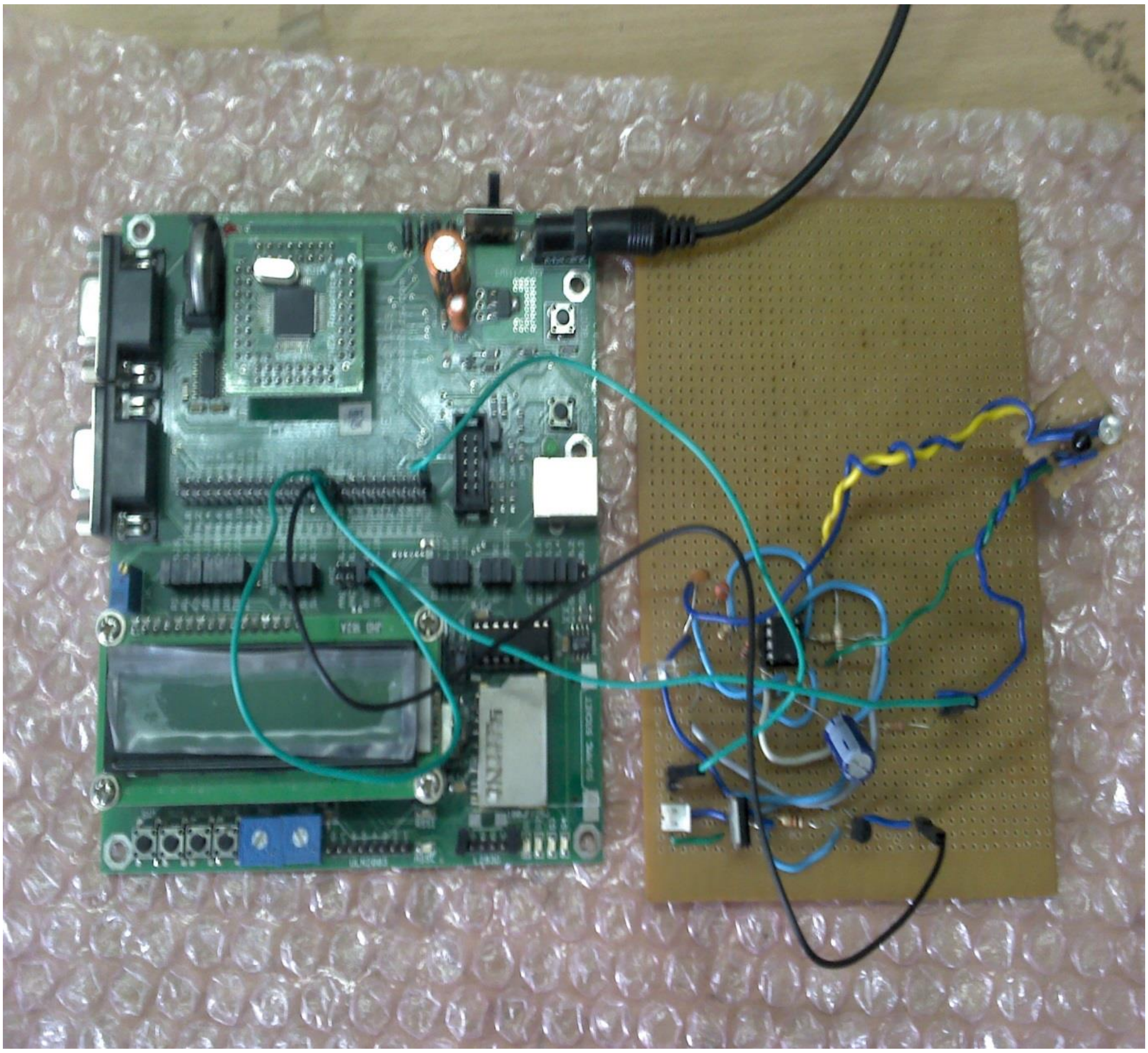

Fig 3.3: Hardware setup

Chapter 4

Results and Conclusion

4.1 Results and Conclusion

Multisensor system designed with the help of LPC2148 microcontroller is a simple yet highly essential circuit which can be used for various purposes such as measuring temperature, obstacle detection, distance measurement and much more. First, the components were bought and tested on bread board and then the final circuit was implemented on Vero board. For different environment conditions, values of sensors were obtained and the results were displayed on LCD.

4.2 Application

- Since every sensor gives some special or specific information, each and every sensor can be used for specific purpose.
- Temperature sensor can be used for critical industrial application such as detecting and controlling temperature of Blast furnace and boiler and providing this information to the control room by buzzer, alarm or some other effective way.
- TSOP IR receiver and IR transmitter can be used for object or obstacle detection, They can be used for obstacle, motion detection, transmitters, encoders, and color detection (such as for line following) and remote sensing.

4.3 Future scope and Enhancement

These sensors can be used in SMART Home appliances to provide better comfort to people. Since ADC contains 16 pins so more sensors analogous to Human sensors can be implemented which can be used in security system, smart lighting system. In other way everything can be made SMART.

In industries this circuit can be used to control temperature automatically without any human need and that too with very less cost. Even Temperature sensors can save electricity by interfacing with various devices by avoiding overheating of device. We can implement some complex Proximity sensor that can be used to detect metals and other specific materials.

Chapter 5

References

5.1 References

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